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Handbook of Instructions

AIL Type 70 Waveguide Noise Generator

March 1960

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ME 221

Airborne Instruments Laboratory
A DIVISION OF CUTLER-HAMMER, INC.
Deer Park, Long Island, New York

HANDBOOK OF INSTRUCTIONS

AIL TYPE 70
WAVEGUIDE NOISE GENERATOR

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I. INTRODUCTION AND DESCRIPTION

The AIL Type 70 Waveguide Noise Generators use argon gas discharge tubes to provide standard noise temperatures of 15.28 db above 290°K, accurate to within ±0.25 db. There are eight Type 70 models that provide a relative excess noise temperature of 15.28 db over a total frequency range of 2,600 to 40,000 Mc (Figures 2 through 9).

The argon gas discharge tube is inserted through the waveguide in a slanted configuration (Figure 1). Appropriate AIL connectors are fitted at the electrodes of the noise tube to permit operation with either the Type 71 Power Supply or with the Type 74 Automatic Noise-Figure Indicator. Standard flanges are used for the noise-output connections and allow coupling to all conventional waveguide equipment. The average VSWR ratings of Type 70 Noise Generators are 1.10 (cold) and 1.05 (hot).

II. OPERATION

Application of the Type 70 as a noise source for performing noise-figure measurements is discussed in Section III, Theory.

III. THEORY

Waveguide noise generators utilize the positive column of a gaseous discharge as a broad-band untuned resistive termination for a waveguide. If the insertion angle of the gas discharge tube is small, there is very little reflec-

tion from the discharge. The minimum insertion angle is determined from the additional consideration that as insertion angle decreases, reflections due to the cutaway guide walls increase.

Performance is optimized by insertion of the discharge tube through the broad faces (E-plane) of the guide. Hence, the greatest linear dimension of the cutaway portion of the guide wall is parallel to the current flow in the wall. This leads to a minimum reflection when the discharge is turned off; thus, transmission through the waveguide section containing the discharge tube is accomplished with negligible loss.

The noise temperature of the gas discharge tube is constant over an ambient temperature range of $-55^{\circ}C$ to $+125^{\circ}C$. A variation of discharge current of the order of ± 20 percent of peak value will produce an average change of relative excess noise temperature of only -0.003 db/ma.

Type 70 Noise Generators can be used in any of the standard setups for performing noise-figure measurements of receivers in the 2,600 to 40,000 Mc range. Basically, these methods involve the measurement of the Y factor, which is defined as the ratio of (1) the noise power from the receiver under test when terminated in a source impedance, at temperature T_2, equivalent to the impedance from which it is intended to work, to (2) the noise power when terminated in the same value of impedance at temperature T_0 ($290^{\circ}K$). When the termination is provided by an argon discharge lamp, T_2 is $10{,}100^{\circ}K$. The full expression for the noise figure of a receiver is then

$$F = \frac{\left(\frac{T_2}{T_0} - 1\right)\frac{B_0}{B} - Y\left(\frac{T_1}{T_0} - 1\right) - \left(\frac{B_0}{B} - 1\right)\left(\frac{T_1}{T_0} - 1\right)}{Y - 1} \qquad (1)$$

where

T_2 = effective temperature of the discharge generator in its fired condition

T_1 = temperature of the termination when the discharge lamp is unfired

T_0 = 290°K

B_0 = over-all noise bandwidth of the receiver under test--including image, harmonic, and other spurious responses

B = useful channel bandwidth of the receiver.

In most cases, this expression can be reduced to

$$F = \frac{\left(\frac{T_2}{T_0} - 1\right)\frac{B_0}{B}}{Y - 1} \qquad (2)$$

because T_1/T_0 is usually almost equal to unity.* If B_0/B is equal to 1, the relation between F and Y that is given in Figure 10 for 10 log $(T_2/T_0 - 1)$ = 15.28 db. If B_0/B is not equal to 1, a correction must be added (in db) to the value obtained in Figure 10 equal to 10 log (B_0/B). For example, if the receiver has an image response equal to the desired signal response (B_0 = 2B), the correction to be added is 3 db.**

Usually, the most accurate means for determining Y is to use the IF attenuation method, as indicated in Figure 11. An IF output is taken from the receiver under test beyond some stage where significant noise cannot be contributed. With the noise generator off, the output from the postamplifier is adjusted to obtain a convenient reading on the output indicator. The generator is then turned on, and

* (T_1/T_0) varies from 0.75 at -55°C to 1.37 at + 125°C.

** Depending on the antenna noise temperature, the operational noise figure may, or may not, be degraded by 3 db for $(B_0 = 2B)$. For a more complete discussion see P. D. Strum, "A Note on Noise Temperature," IRE Trans, MTT, p 145-151, July 1956.

the IF attenuator is adjusted to return the output indicator to the preceding value. The change between the two conditions is precisely the Y factor, provided that all circuits up to the attenuator are linear and that the gain of the over-all system has remained constant during the two measurements.

The accuracy of the measurement is also dependent upon the accuracy of the attenuator that is used. The AIL Type 30 IF Attenuator is excellent in this application. This attenuator has been incorporated in a 30-Mc (or 60-Mc) receiver (AIL Type 132), which also includes the post-amplifier and output indicator shown in Figure 11.

In this discussion, it is assumed that the effective temperature of the generator is equal to that of the discharge. This is true if the coupling to the discharge is complete. If this is not the case, there is an effective reduction in the output noise. A measure of this coupling is the insertion loss of the generator in the fired condition. This loss, which is easily measured, provides the best means of computing this correction. The expression for this reduction is

$$\frac{t_g - 1}{t_d - 1} = 1 - \frac{1}{L_H}^*$$

where t_g is the relative noise temperature of the generator (defined as the ratio of the noise temperature to T_0), t_d is the noise ratio of the discharge, and L_H is the hot insertion loss of the generator. This expression is plotted in

---

* This assumes that there is no loss in the unfired condition, or that the loss in the fired condition is considerably higher than that in the unfired condition.

Figure 12 as the db reduction in excess noise-power output as a function of L_H in db. This value should be subtracted from the noise figure computed from Figure 10.

NOTE

1. Type 70 Noise Generators must be terminated in a matched load with an SWR of less than 1.10 to obtain accurate results. Otherwise, the impedance of the generator will not be the same in both the "on" and "off" conditions, and the measurements will not be valid. In some cases, it is desirable to be able to align the receiver under test before each measurement. In this case, a carefully matched 20-db pad can be connected to the unused terminal in place of the 50-ohm termination, and a signal can then be fed through the pad and noise generator to the receiver.

2. If the generator is to be used continuously, it may cause the termination temperature (T_1) to rise significantly above 290°K. If extreme accuracy is required and if the receiver noise figure is low (below 6 db), this increase in termination temperature may require a correction to the measured noise figure computed from equation 2. Equation 1 must then be used; the correction is seldom significant.

IV. MAINTENANCE

Maintenance of all Type 70 Noise Generators except the 07096 is limited to removal, replacement, and care of the argon gas discharge tube. In the case of the 07096, the entire Noise Generator Unit should be returned directly to the factory for all repairs.

Field maintenance procedure is as follows. If the tube does not fire or operates improperly, it should be removed from the housing and inspected. To remove the gas tube from the interior of the generator housing, unscrew the filament connector sleeve (Figure 1), then guide the tube

out carefully, without exerting great force. When the tube is removed, place it on a soft material and inspect the envelope, the high-voltage contact (anode), and the filament pins. Check the envelope for possible leakage or breakage. Loose, corroded, or pitted contacts may be responsible for tube failure. Corroded contacts can be cleaned with crocus cloth or similar (abrasive) material. If the anode is corroded or pitted, remove the anode mount from the housing and inspect the internal spring. If failure is not attributed to any of the external parts of the tube, internal tube defects or the mount assembly may be the cause of the trouble.

When it is necessary to replace the argon gas discharge tube, carefully inspect the new tube and make sure that it is of the same type as the original tube (Figure 13). To replace the gas tube, slide it gently into the generator housing until the tube is fully seated against the internal spring in the anode mount. The filament connector sleeve should then be screwed onto the housing so that the end of the cathode connector is in 3/8 inch from the end of the filament connector sleeve. The locking ring should then be rotated to lock the filament connector sleeve to the housing.

V. PARTS LIST

The only components in the Type 70 Noise Generators that can be replaced are the argon gas discharge tube (see Figure 13 for AIL part number) and (for the Type 07048), the noise tube cathode adapter (AIL part number 112977-3).

VI. ACCESSORIES

High-Voltage Cable	AIL Part Number 3471-02C31
Low-Voltage Cable	AIL Part Number 3471-02C22

VII. RETURN OF EQUIPMENT TO FACTORY FOR REPAIRS

If it becomes necessary to return any equipment to the manufacturer for repairs, please write first to the AIL Sales Department, giving complete information concerning the nature of the failure and the manner in which the equipment was used when failure occurred. Also provide the TYPE and SERIAL NUMBERS of the unit. Special instructions will then be supplied to the customer for shipping the unit back for repairs. All equipment should be packed and shipped, in accordance with these instructions, with transportation charges prepaid. A failure report should accompany shipment of the equipment.

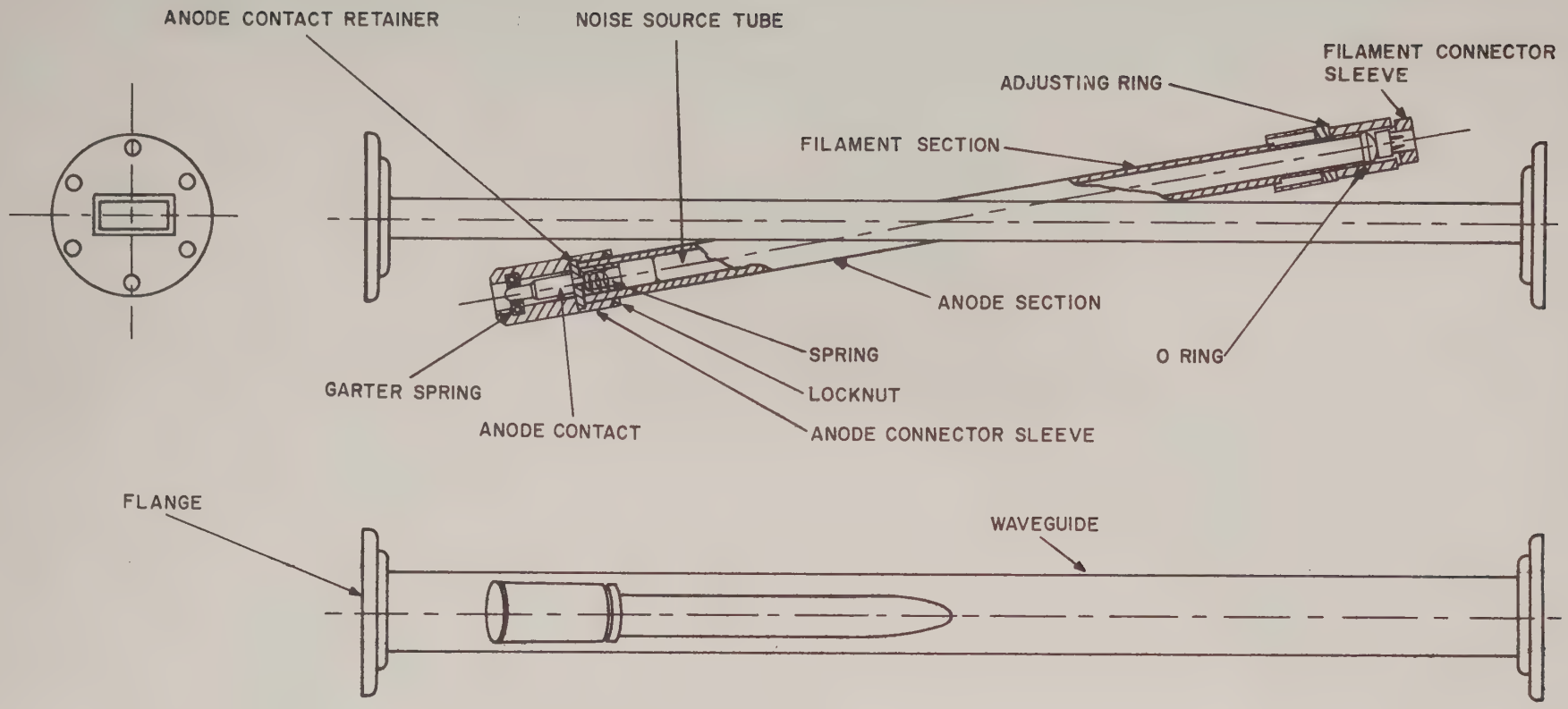
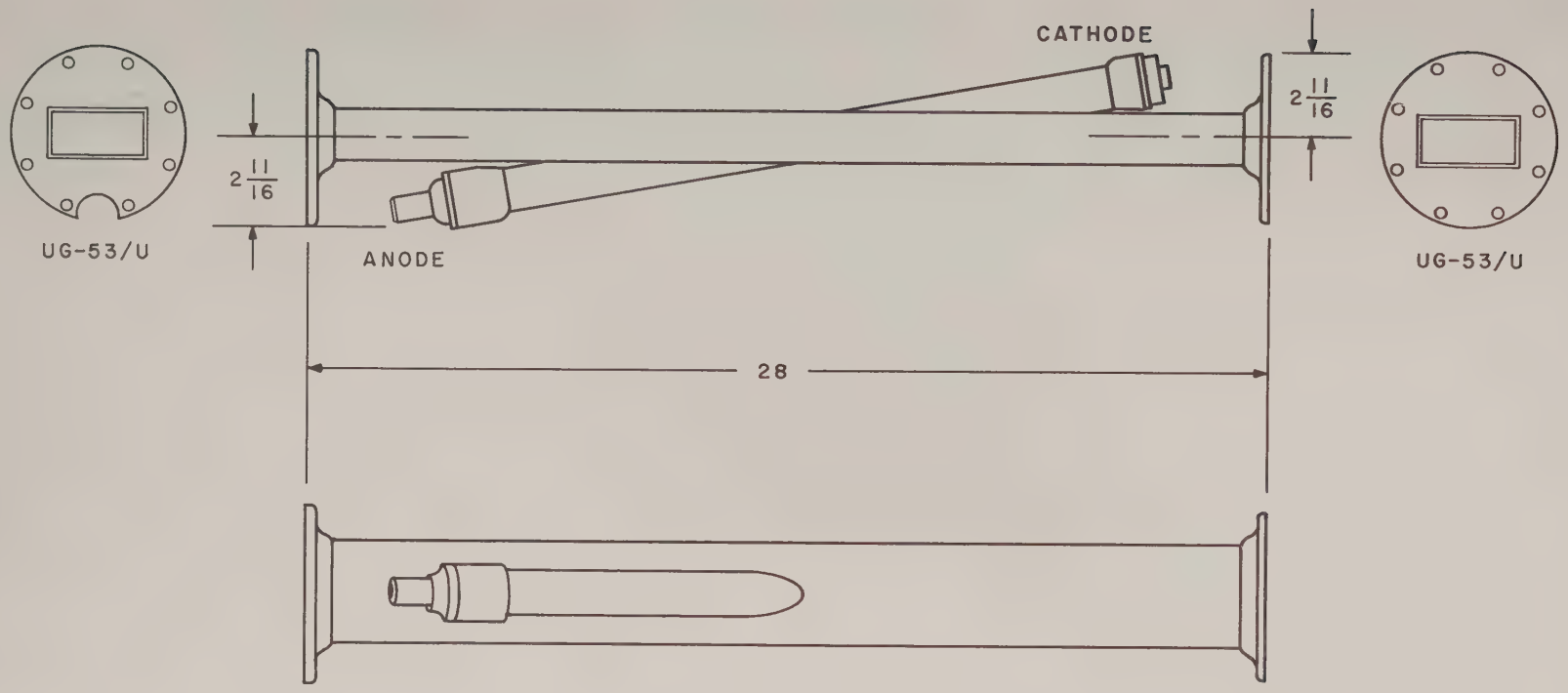


FIGURE 1. TYPICAL AIL TYPE 70 WAVEGUIDE NOISE GENERATOR ASSEMBLY

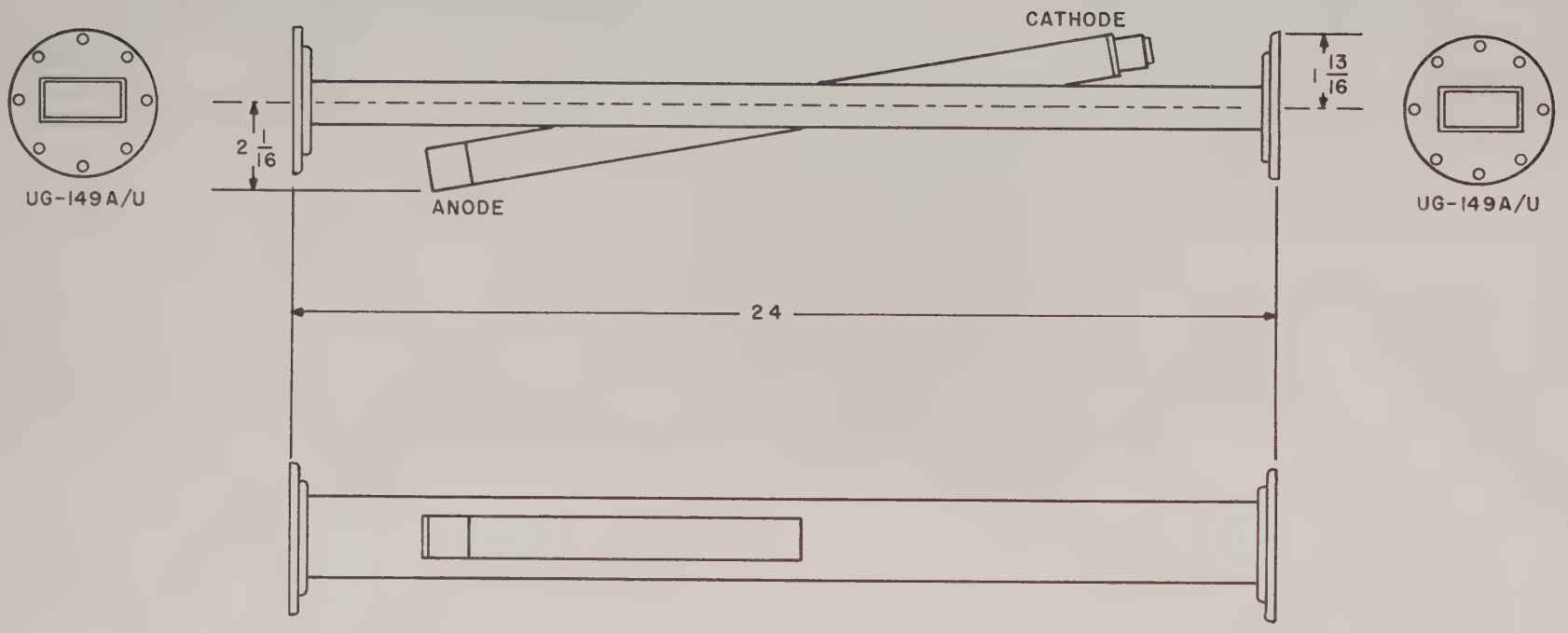


AVERAGE VSWR: HOT, 1.03; COLD, 1.06
ARGON TUBE: AIL PART NO. 112990
WAVEGUIDE SIZE: RG-48/U
TUBE VOLTAGE DROP: 145 VOLTS
ANODE CURRENT: 200 MA

ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/5

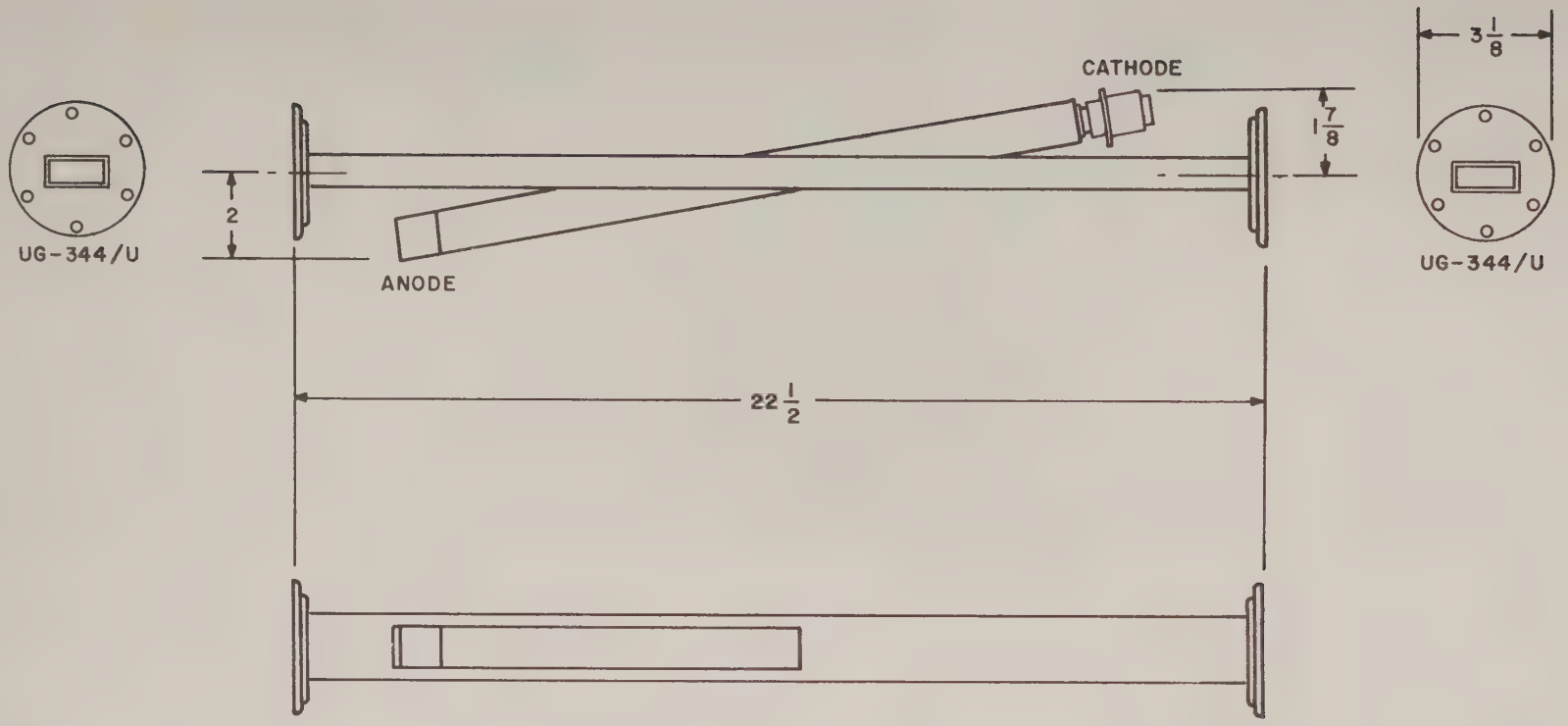
FIGURE 2. TYPE 70; 2600 TO 3950 MC WAVEGUIDE NOISE GENERATOR PART NO. 07048



AVERAGE VSWR: HOT, 1.03; COLD, 1.06
ARGON TUBE: AIL PART NO. 113827
WAVEGUIDE SIZE: RG-49/U
TUBE VOLTAGE DROP: 135 VOLTS
ANODE CURRENT: 175 MA

ALL DIMENSIONS ARE GIVEN IN INCHES
SCALE: 1/4

FIGURE 3. TYPE 70; 3950 TO 5850 MC WAVEGUIDE NOISE GENERATOR PART NO. 07049

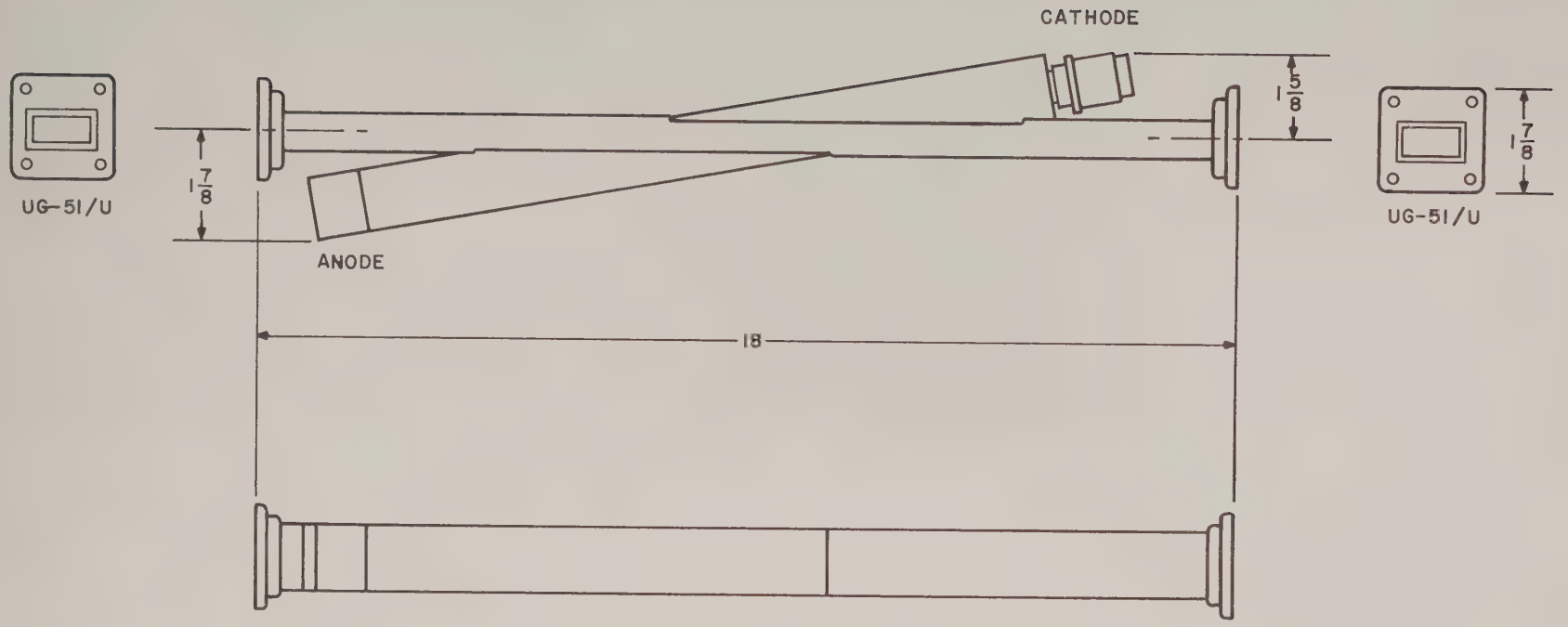


AVERAGE VSWR: HOT, 1.03 ; COLD 1.06
ARGON TUBE: AIL PART NO. 113827
WAVEGUIDE SIZE: RG-50/U
TUBE VOLTAGE DROP: 135 VOLTS
ANODE CURRENT: 175 MA

ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/4

FIGURE 4. TYPE 70', 5850 TO 8200 MC WAVEGUIDE NOISE GENERATOR PART NO. 07050

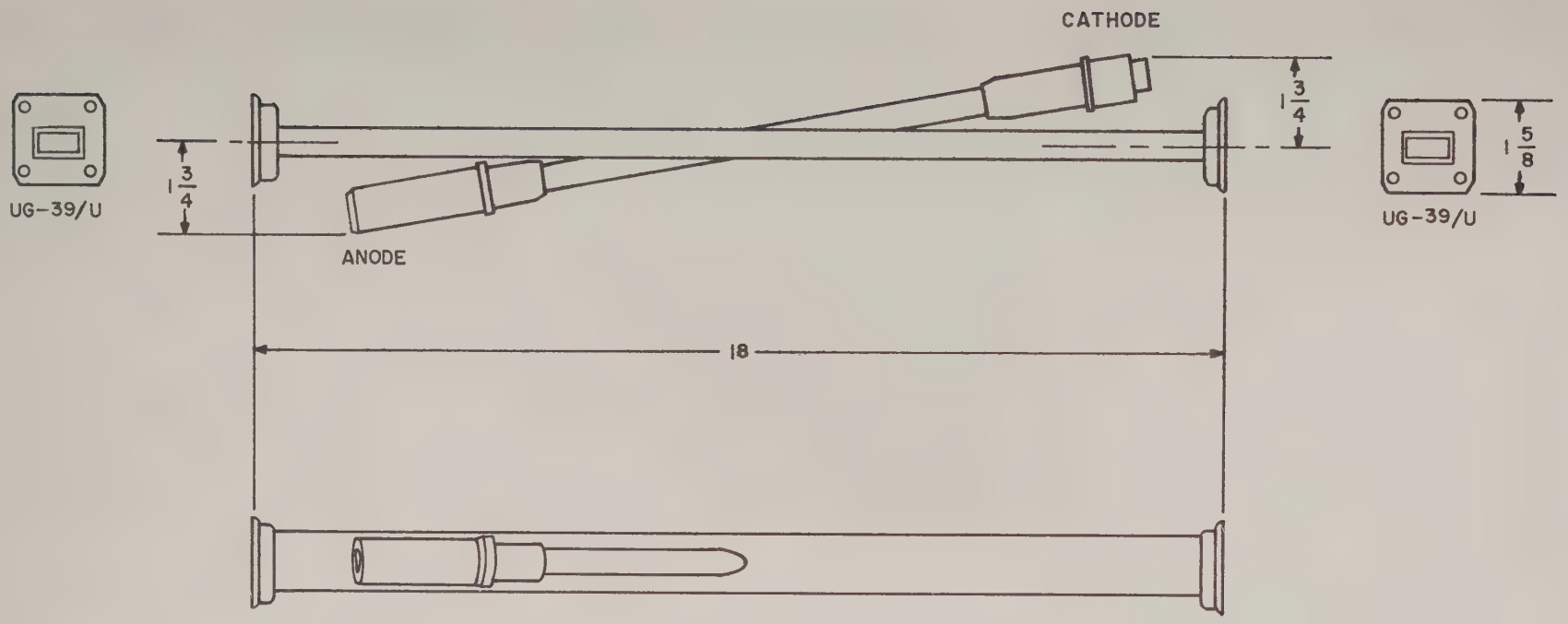


AVERAGE VSWR: HOT, 1.03; COLD, 1.06
ARGON TUBE: AIL PART NO. 112307
WAVEGUIDE SIZE: RG-51/U
TUBE VOLTAGE DROP: 130 VOLTS
ANODE CURRENT: 175 MA

ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/3

FIGURE 5. TYPE 70; 7050 TO 10,000 MC WAVEGUIDE NOISE GENERATOR PART NO. 07051

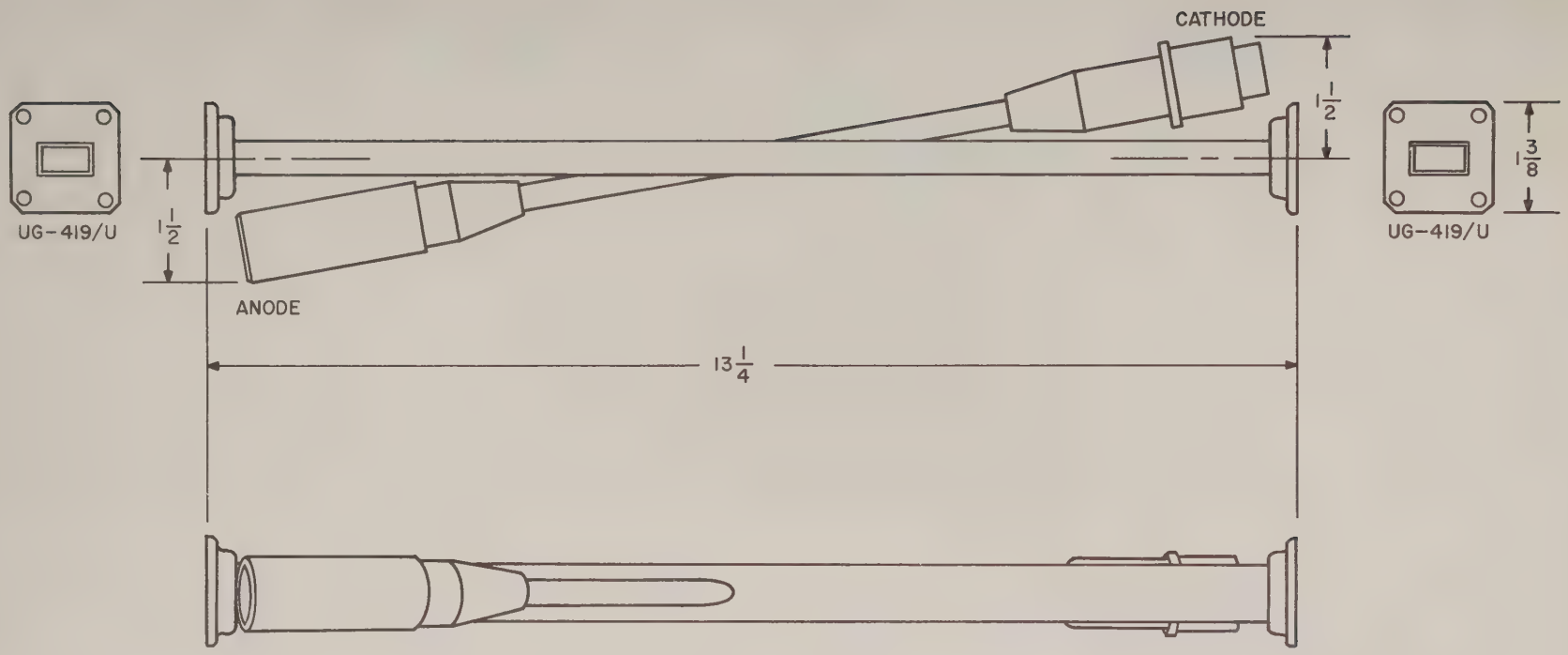


ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/3

ARGON TUBE: AIL PART NO. 112307
WAVEGUIDE SIZE: RG-52/U
TUBE VOLTAGE DROP: 130 VOLTS
ANODE CURRENT: 175 MA

FIGURE 6. TYPE 70, 8200 TO 12,400 MC WAVEGUIDE NOISE GENERATOR PART NO. 07052

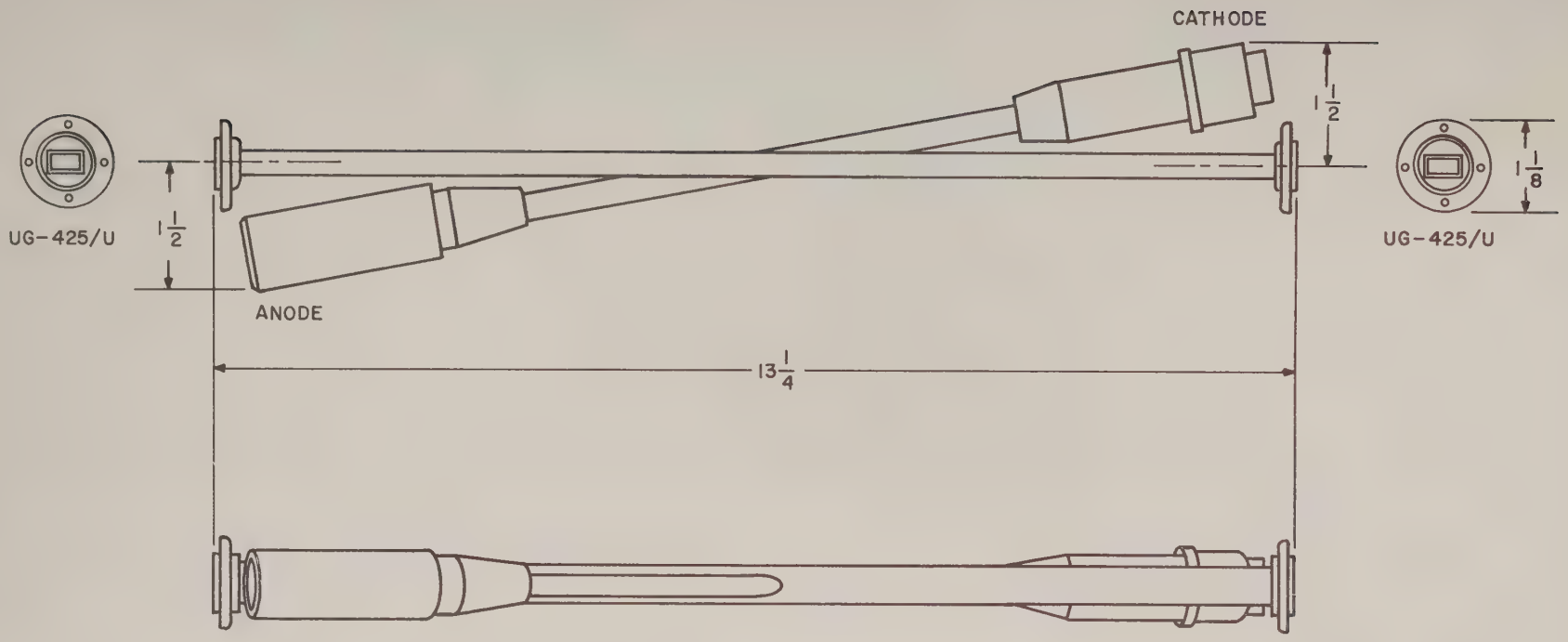


AVERAGE VSWR: HOT, 1.06; COLD, 1.10
ARGON TUBE: AIL PART NO. 112434
WAVEGUIDE SIZE: RG-91/U
TUBE VOLTAGE DROP: 125 VOLTS
ANODE CURRENT: 175 MA

ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/2

FIGURE 7. TYPE 70, 12,000 TO 18,000 MC WAVEGUIDE NOISE GENERATOR PART NO. 07091

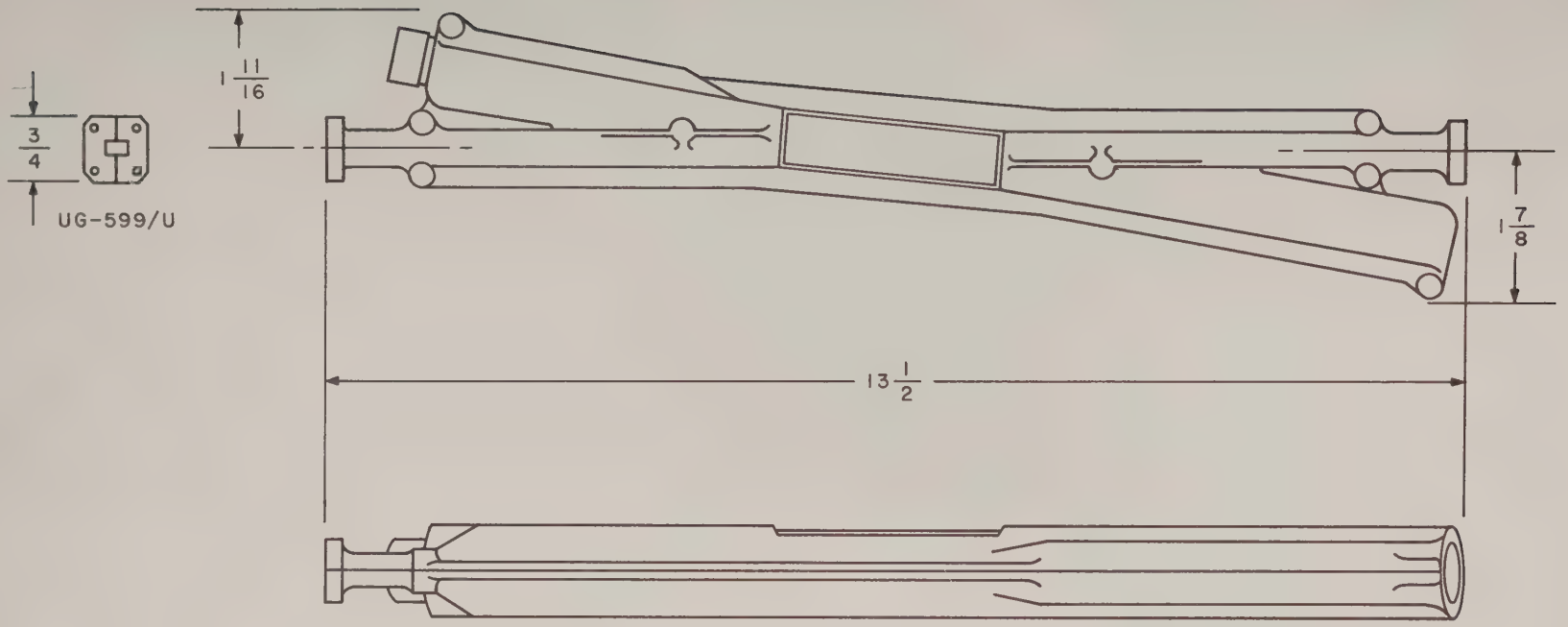


AVERAGE VSWR: HOT, 1.10; COLD, 1.15
ARGON TUBE: AIL PART NO. 112434
WAVEGUIDE SIZE: RG-53/U
TUBE VOLTAGE DROP: 125 VOLTS
ANODE CURRENT: 175 MA

ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/2

FIGURE 8. TYPE 70; 18,000 TO 26,500 MC WAVEGUIDE NOISE GENERATOR PART NO. 07053



ARGON TUBE: AIL PART NO. 114410
WAVEGUIDE SIZE: RG-96/U
TUBE VOLTAGE DROP: 175 VOLTS
ANODE CURRENT: 100 MA

ALL DIMENSIONS ARE GIVEN IN INCHES

SCALE: 1/2

FIGURE 9. TYPE 70; 26,000 TO 40,000 MC WAVEGUIDE NOISE GENERATOR PART NO. 07096

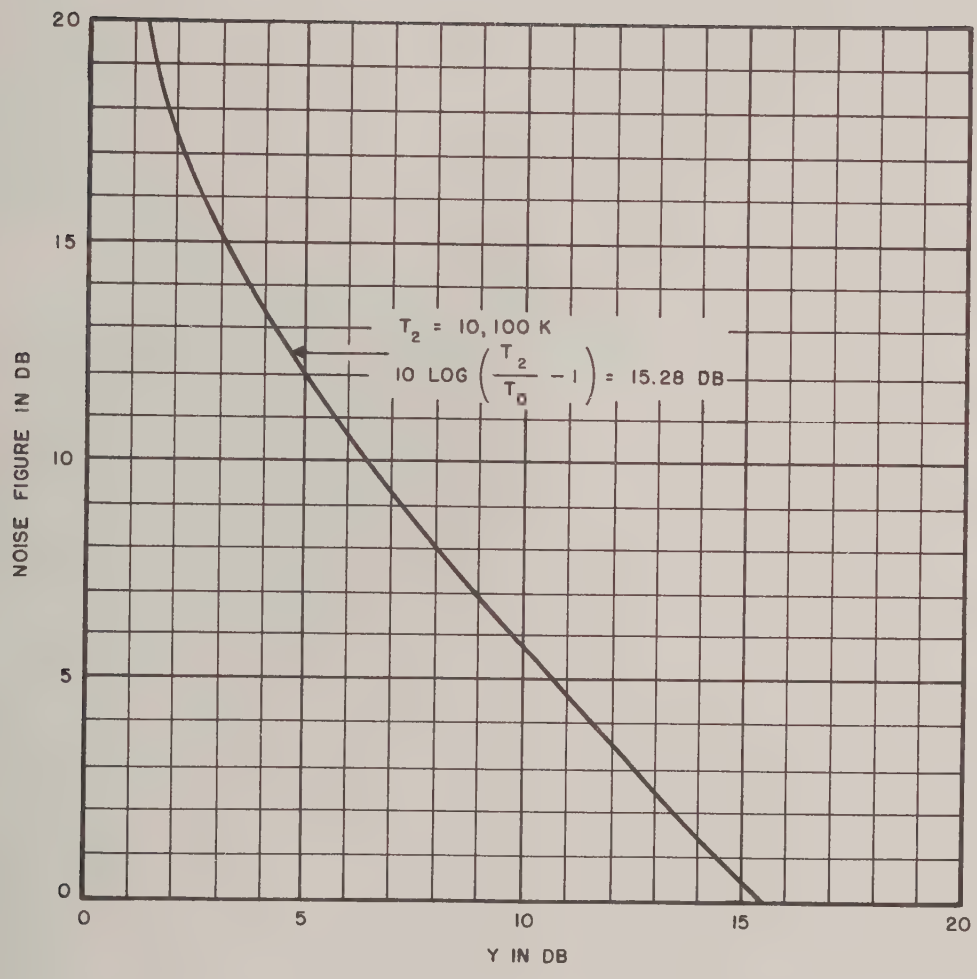
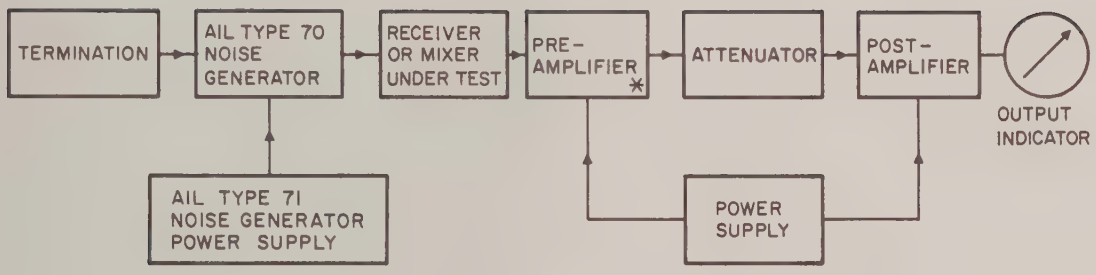


FIGURE 10. Y FACTOR VS NOISE FIGURE FOR 15.28-DB NOISE SOURCE



*NOT REQUIRED IF PREAMPLIFIER IS PART OF DEVICE UNDER TEST.

FIGURE 11. TEST SETUP FOR MEASUREMENT OF NOISE FIGURE

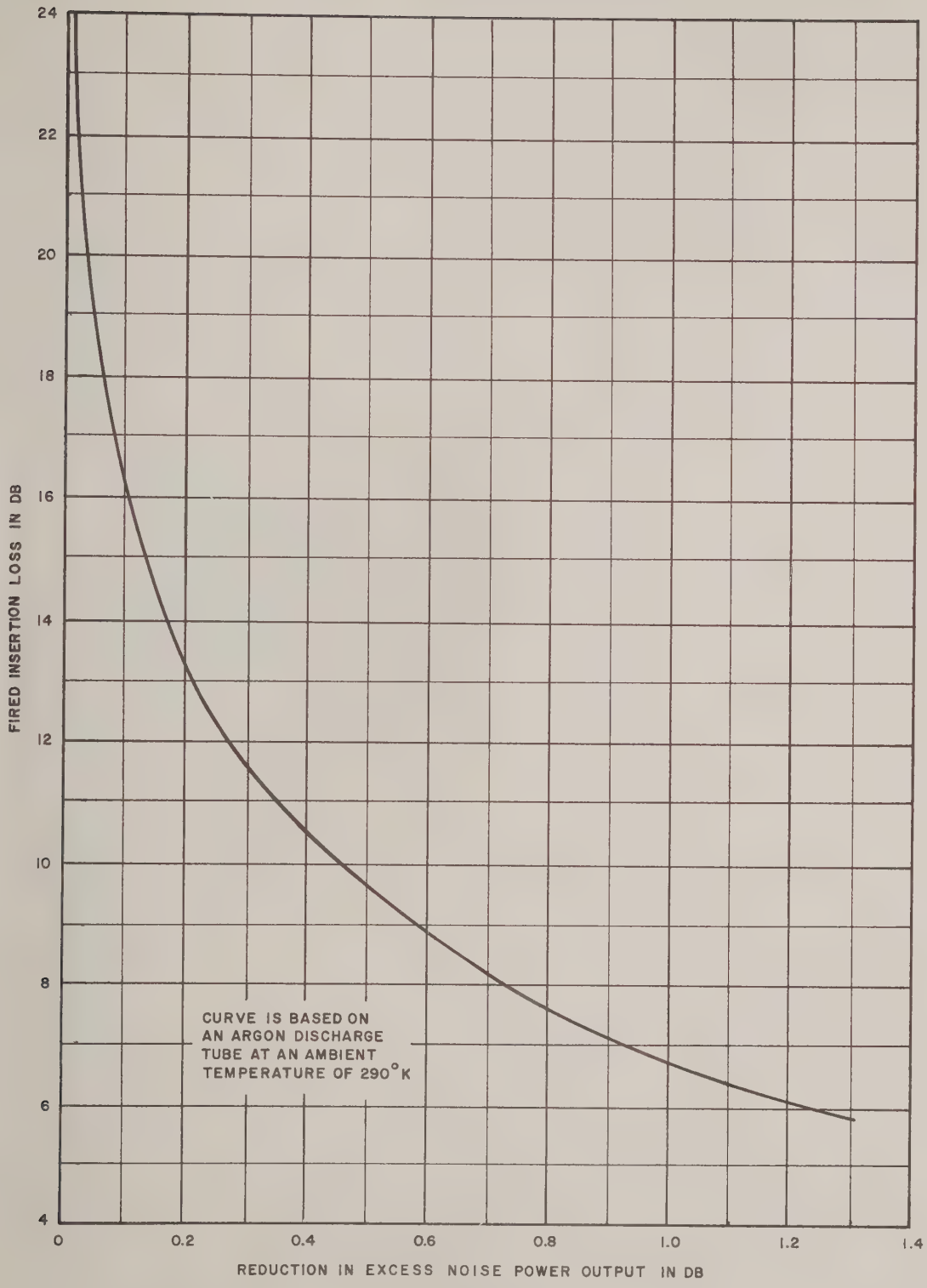


FIGURE 12. FIRED INSERTION LOSS VS REDUCTION IN EXCESS NOISE POWER OUTPUT

AIL Tube Part No.	Used in AIL Noise Generator Part No.	Tube Length (inches) Maximum	Minimum	Tube Voltage Drop (volts)	Peak Anode Current (ma)	Tube Dissipation (watts)
112307	07051 07052	12-1/4	11-15/16	130	175	11.5
112434	07053 07091	10	9-11/16	125	175	11.0
112990	07048	18	17-5/8	145	200	14.5
113827	07049 07050	15	14-3/4	135	175	12.0
114410	07096	9-5/8	9-1/8	175	100	9.0

FIGURE 13. DATA ON ARGON GAS DISCHARGE TUBES